WASTES MANAGEMENT IN PROVINCEOF TORINO

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R. CONTI*, G. FILIPPINI**, C. MOLLEA* AND P. MOLINA**

**Department of Materials Science and Chemical Engineering, Polytechnic of Torino – Corso Duca degli Abruzzi, 24, 10129, Torino, Italy*
***Provincia di Torino, Area Ambiente, Parchi, Risorse Idriche e Tutela della Fauna - Via Valeggio 5, 10128 Torino, Italy*

SUMMARY: Waste disposal in Province of Torino is atypical respect to other Provinces of northern Italy since it is still based on landfilling. In order to redesign waste management, in 1997 source separation of waste was promoted according to a "*road"* ("stradale") modality, which has yielded not so homogeneous and satisfactory results. For this reason, in order to improve the separate collection, the "*door to door"* ("porta a porta") modality has been activated in last years and it is in course of experimentation. The present work shows the analysis of source separation trend in the Province on the basis of results obtained between 1997 and 2004. This allowed to develop a model to interpret and foresee source separation evolution. Moreover, on the basis of the working plants available in the Province territory, the model also allows to plan the necessity of new plants in particular regard to biological ones.

1. INTRODUCTION

Waste disposal in Province of Torino is still based on landfilling thanks to a good number of landfills of adequate capacity, built or enlarged in past years. This is due to a series of continual adjournments which have allowed to maintain this kind of organization, unlike other Provinces in Northern Italy (e.g. two incineration plants in 1997 were operative in Province of Milano).

The Province territory is divided into ten basins (bacini) (Figure 1): in each basin a consortium (consorzio), which represents the first level of waste management, is operating. By this way, the tasks of basin services (servizi di bacino) are: the realization and management of structure for source separation (SS), the source separation activity and waste collection, transport and distribution of waste to technological plants. The main characteristics of each basin are listed in Table 1.

As it is possible to notice (Table 1), 40% of the entire Province population (2.173.019 inhabitants) and 45% of the total waste production (1.131.904 tons/ year) are referred to the city of Torino (basin 18): in this basin also the residual volumetry of the landfill (m^3) and the potentiality of the active plants for biological treatments (tons/ year) are the largest of the Province. Landfills are present in each basin with the exception of basin 14 (a landfill – 450.000 m^3 – has been approved and it needs to be localized) and 17C (the existing landfill is actually full and wastes are disposed outside the Province). Regard to biological treatments, while active

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Table 1. Main characteristics of the ten basins for the waste management in Province of Torino: inhabitants, waste produced (tons/ year), residual volumetry of landfills (m^3) and potentiality of active composting and anaerobic digestion plants (tons/ year). ([a]Banca dati evolutiva Regione Piemonte anno 2002; [b]Authorizations ex art. 27/28 d.lgs. 22/97; [c]Authorizations ex art. 33 d.lgs. 22/97)

Basin	Consortium	Inhabitants[a]	Waste produced	Landfills residual volumetry	Composting plants potentiality[b]	Composting plants potentiality[c]	Anaerobic digestion plants potentiality[b]
12	ACEA	142.701	72.039	61.524	20.000	5.000	15.000
13	CCS	112.481	50.750	209.000	-	24.500	-
14	COVAR 14	242.842	115.826	-	-	25.500	-
15A	CADOS	214.820	107.310	241.047	10.000	-	-
15B	ACSEL	79.844	45.429	248.154	-	5.000	-
16	Consorzio Bacino 16	242.841	119.393	177.801	-	9.500	-
17A	CISA	91.071	40.928	126.673	-	7.500	-
17B-D	CSAC	76.945	37.768	40.700	-	7.000	-
17C	CCA	107.830	49.156	-	21.000	18.000	-
18	TORINO	861.644	493.305	1.420.000	40.000	10.500	-

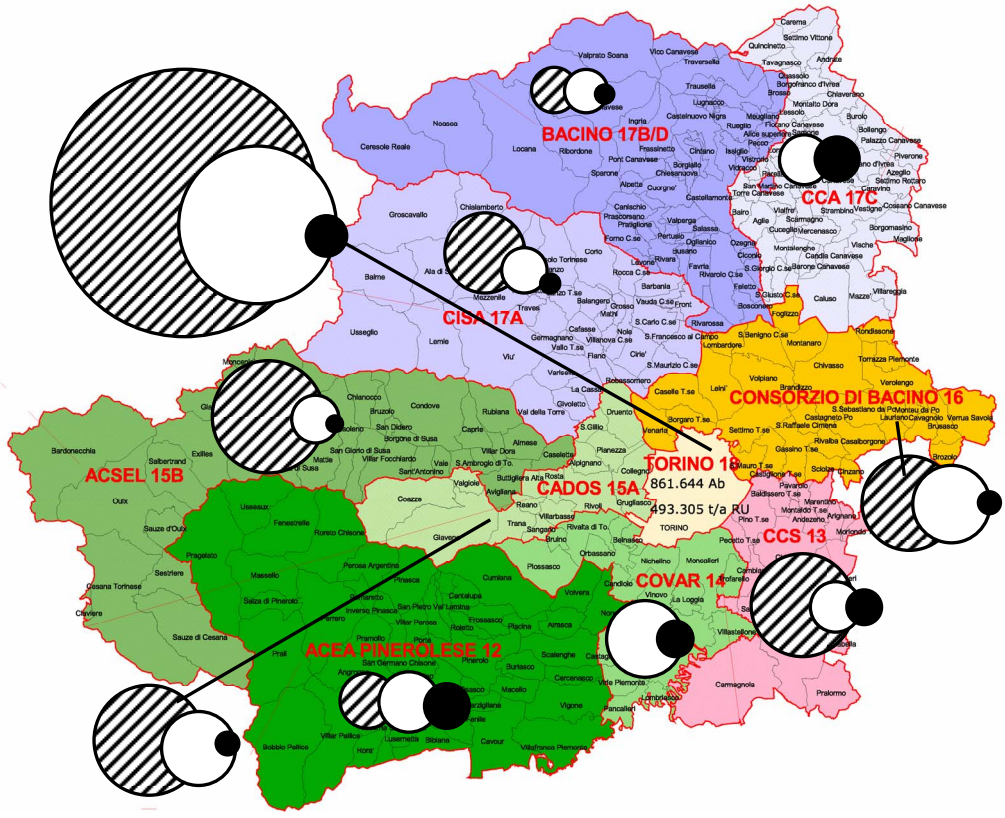

Figure 1. Total waste produced (tons/year, white circles), landfill residual volumetry (m^3, striped circles) and biological treatment plants potentiality (tons/year, black circles) in Province of Torino and its division into ten Basins.

Table 2. Basins grouping into Planning areas. ([a] Banca dati evolutiva Regione Piemonte 2002).

Planning areas	Basins	Inhabitants (2003)[a]	Waste (t/y)	Waste disposal capacity (m^3)
South-West	12, 14, 15A, 15B	275.846	340.604	550.725
South-East	13,16,18	1.216.966	663.448	1.806.801
North	17A, 17B-D, 17C	680.207	127.852	167.373

composting plants with different capacities are arranged over all the basins, only one anaerobic digestion plant is present (basin 12).

Total waste production and disposal capacity of each basin at the end of 2003 are also showed in Figure 1. The disposal capacity is referred to landfills residual volumetry (m^3) and potentiality (tons/ year) of active plants for the biological treatments (Authorizations ex art. 27-28 D. Lgs. 22/97; Authorizations ex art. 33 D. Lgs. 22/97).

On the basis of the "Provincial Program for Waste Management" (Programma Provinciale di Gestione dei Rifiuti - D.C.P. n. 413-109805, 1998) currently in force, basins are grouped into more extensive territorial zones called planning areas (aree di pianificazione) as indicated in Table 2. Planning areas have been defined taking into account the morphological and social characteristics of the Province territory. The three planning areas represent the second level of waste management and are delegated to the realisation and management of treatment plants and final disposal of waste (thermal treatment of the combustible fraction and landfilling of the treatment residuals). The planning areas will decay when a sole ambit institution (istituzione d'ambito) for all the Province will be established (D.C.P. 59245 del 30.03.2004). The principal task of the ambit services (servizi d'ambito) is the realization and management of waste recycling and disposal plants (L.R. Piemonte 24 ottobre 2002, n. 24, *Norme per la gestione dei rifiuti*). However, planning areas, as distinct management zones, represent the most useful distribution of the Province which consent to close the entire cycle of waste management avoiding long distances when wastes are moved for their treatment or disposal.

2. SOURCE SEPARATION

The considerable residual volumetry of landfills and in particular that of AMIAT S.p.A. (Azienda Multiservizi Igiene Ambientale Torino), which serves the city of Torino (basin 18), has enabled to protract the waste management based on landfilling beyond normality.

At this moment very large amounts of wastes are accumulated in the original landfills, by far larger than planned by the "Provincial Program for Waste Management"; therefore a new elaboration of the Program is due.

In order to face this situation, the Province of Torino in recent years has endeavoured to promote at the most the source separation of waste; in 1997 the source separation was induced in accordance with the related set of rules in force (D. Lgs. 22/97). The results obtained at the start up were not homogeneous, in particular regard to single communes, and disappointing on the average. Source separation data (%) for years from 1997 to 2003 are indicated in Table 3. The values % are calculated respect to the total waste produced in each basin; for each year, the average value of every basin and that of the two communes which overtook the highest and the lowest source separation % are listed (for basin 12 only the average value is reported). The first column is referred to 1997, in that year the legislative decree number 22/ 97, known as "Decreto Ronchi", came into force. This set of rules has provided as objectives for source separation (art. 24 comma 1): 15% by 1999, 25% by 2001 and 35% with effect from 2003. Observing averages in Table 3, it is possible to notice that in the course of the years they were below the objectives.

Table 3. Source separation data (%) in the ten basins of the Province of Torino from 1997 to 2003. ([d] the two average values are referred to two different consortia which have been grouped into Consorzio bacino 16 since 2004).

		SS %						
Basin		1997	1998	1999	2000	2001	2002	2003
12	average	9,6	12,1	16,5	11,8	17,9	19,4	29,1
13	average	6,7	9,3	10,9	15,7	17,3	20,5	25,2
	the best	25,0	31,1	20,5	37,3	37,7	42,7	59,3
	the worst	0,0	1,3	2,9	3,6	5,6	6,8	6,9
14	average	6,0	8,3	10,1	13,0	15,2	20,1	22,5
	the best	18,3	26,3	26,0	29,7	35,5	34,5	34,4
	the worst	4,3	6,1	6,9	8,1	9,2	12,9	15,5
15A	average	7,2	13,8	16,1	17,2	19,7	21,8	25,9
	the best	15,8	19,5	25,9	30,6	40,2	41,7	47,8
	the worst	0,0	9,8	14,0	16,0	15,5	16,9	16,2
15B	average	3,2	5,8	9,2	10,0	13,1	17,0	17,6
	the best	11,6	25,3	33,2	28,2	53,6	37,2	37,4
	the worst	0,0	1,3	3,5	2,4	5,7	2,8	2,6
16	average[d]	1,4-5,9	7,0-8,1	9,0-10,4	11,2-14,0	13,4-16,4	18,9-18,5	18,3-25,2
	the best	12,0	15,9	14,4	19,0	24,8	27,2	38,4
	the worst	0,0	4,0	4,3	5,4	5,5	6,0	8,8
17A	average	3,4	6,5	9,2	12,0	14,7	18,1	22,9
	the best	16,8	15,1	23,0	27,2	28,3	32,4	54,2
	the worst	0,0	0,0	0,0	0,0	0,3	7,2	2,5
17B-D	average	0,7	5,2	13,8	15,6	16,6	17,5	24,0
	the best	15,1	10,7	22,8	21,0	21,5	24,5	34,9
	the worst	0,0	0,7	0,3	5,3	8,3	4,2	13,8
17C	average	7,8	9,2	10,5	14,9	17,5	22,9	27,3
	the best	15,2	16,5	23,0	25,2	28,9	36,2	50,8
	the worst	0,0	0,0	0,7	0,0	9,4	12,8	12,6
18	TORINO	12,5	15,7	19,0	22,4	24,9	24,6	26,1

Considering the best values, they are sometimes really greater than the objectives % but they are referred to some communes of each basin or they were achieved in singular years and do not maintained in the subsequent ones. At the same time, worst values are really low and sometimes equal or near zero indicating respectively that the source separation was not activated or showed an initial failure. Finally, data referred to the city of Torino (basin 18) are relatively high respect to other basins with several communes, but they belong only to some quarters were the source separation was activated and supervised with particular care.

2.1 Source separation conducted with the "*road*" modality

On the basis of results trend showed in Table 3, the Province of Torino has deemed necessary to start the development of a new model of waste management by improving the source separation

Table 4. owns division into classes on the basis of inhabitants number.

Class	Inhabitants	Number of towns	Inhabitants %
A	≤3.000	215	10
B	3.000<÷≤ 20.000	87	26
C	>20.000	13	24
D	TORINO	1	40

in order to obtain better results respect to the initial ones. At the same time the Piemonte region determined to attain the objective of 50% of source separation by 2009.

At present time, source separation in Province of Torino is mainly conducted according to a *road* (stradale) modality: suitable containers for each separate fraction are settled in the streets at users disposal. From the beginning results of source separation have grown and recently they have shown gradients particularly high, but considering the overall trend it seems impossible to attain the regional objectives. This conclusion descends from data analysis conducted considering the behaviour of separate communes in the period between 1997 and 2003 (Table 3).

On the basis of the conducted analysis and in order to better understand the behaviour of different kind of communes of the Province, they were divided into four classes depending on the number of inhabitants (Table 4). As a matter of fact, for each class including several communes (A, B, C) various behaviours exist which lead to different results of source separation. In particular, the structure of the residential installation and the territorial distribution of the population hold a remarkable importance for the purpose of waste management planning. The Province of Torino is fragmentary from the administrative point of view since it has 316 communes, with different characteristics, which is by far the highest number in Italy. This is due to wide mountain areas and its orographic structure. There are a lot of small (30% of communes with 1000<÷<3000 inhabitants) and very small (40% of communes with <1000 inhabitants) communes, while medium ones are few (4% of communes with >20.000 inhabitants) and are integrated in the neighbourhood of Torino. About 94% of population is organized into urban centres and the remaining 6% resides in minor groups and dispersed houses. Those areas with a scattered installation scarcely affect waste production, but they cover a significative part of the territory and are of great interest for all the local bodies. On the basis of those territorial characteristics, a specific management of waste collection is needed, in particular regard to relatively dispersed touristic areas producing significative quantities of waste.

Figures 2 a, b and 3 show that, the evolutionary trend of source separation seems to be substantially the same for all the communes belonging to a certain class. Which means that the trend of source separation % in the course of years can be represented with a sole curve for each class; each commune of a certain class runs along the curve at the same velocity, but with different starting points depending on the source separation % obtained in 1997.

This statement is at the basis of the interpretative method proposed: a sole mathematical correlation with three sets of parameters that explains the behaviour of the classes including several communes (A, B, C). This method might provide more adequate results if a constant but specific velocity was considered for each commune as well as the starting point on the curve; notwithstanding that the chosen one is more simple and anyhow shows classes behaviours in a satisfactory way. The correlation is the following (eq. 1):

$$y = \frac{a}{1 + e^{-\left(\frac{x - x_0}{b}\right)}} \qquad \text{(eq. 1)}$$

x represents the time evenly expressed in years for each commune; y is the source separation % in the x year calculated by the reference one for each commune (the reference year is determined on the basis of source separation data, experimentally achieved, in the considered commune). Parameters a, b, and x_0 (Table 5) were determined experimentally for each class: the average source separation % (1997-2003) was calculated for sample communes (data not shown) of each class; those data were inserted in a diagram in an increasing order of source separation % observing the time scale. Following, yearly source separation % values of each commune were arranged around respective average ones; the group of all points was finally interpreted with the curve of the sub cited correlation (eq. 1). As an example, curve trends for classes A and C together with data belonging to some communes of each class are reported in Figure 2a, b (for class C data of all the communes of the Province are reported). The correlation used enabled to predict in a reliable way source separation trend in the Province of Torino in next years; the prevision inclines to suppose that the objective of 50% of source separation, determined by the Piemonte region, will be reached hardly with the *road modality* currently in use. As a matter of fact, only classes A and B can overcome 50% of source separation in not short time (asymptotic values are near 53% of source separation, Figure 2a). While classes C and D are not supposed to overcome that value (the asymptotic value of class C corresponds to 39% of source separation, Figure 2b).

2.2 Source separation conducted with the *"door to door"* modality

Various factors (external, normative and/or coercive) can affect source separation trend and modify its results, yet limitations of the source separation conducted with a *road* modality are difficult to be exceeded even if some communes, generally with few inhabitants, prove virtuous behaviours. For this reason, the Province of Torino decided to start a different kind source separation, called *door to door* (porta a porta): separate waste fractions are collected directly at users houses. The experimentation started almost at the same time in some communes of the Province and in some quarters of Torino.

First results are coherent with those recorded in other regions of Italy (e.g. Veneto, Campania) and demonstrate that in small and very small communes with the *door to door* modality the 50% of source separation can be easily exceeded, obtaining also higher values usually included between 60 and 70% of source separation. Those last values are difficult to be improved, for this reason the curves tend to assume a "step" shape: at the transition from the *road* to the *door to door* modality a sharp turn from the principal curve is evident followed by a settlement. In Figure 3 source separation data from 1997 to 2004 for some communes of class B are arranged on the typical curve of the class, while the "step" shape, due to the transition to the *door to door* modality, is showed for three communes (Caselle, Giaveno and Rosta).

Table 5. Values of parameters a, b and x_0 (eq. 1).

Classes	a	b	x_0
A	$5{,}34*10^{-1}$	2,59	8,59
B	$5{,}33*10^{-1}$	3,16	8,77
C	$3{,}88*10^{-1}$	5,42	9,85

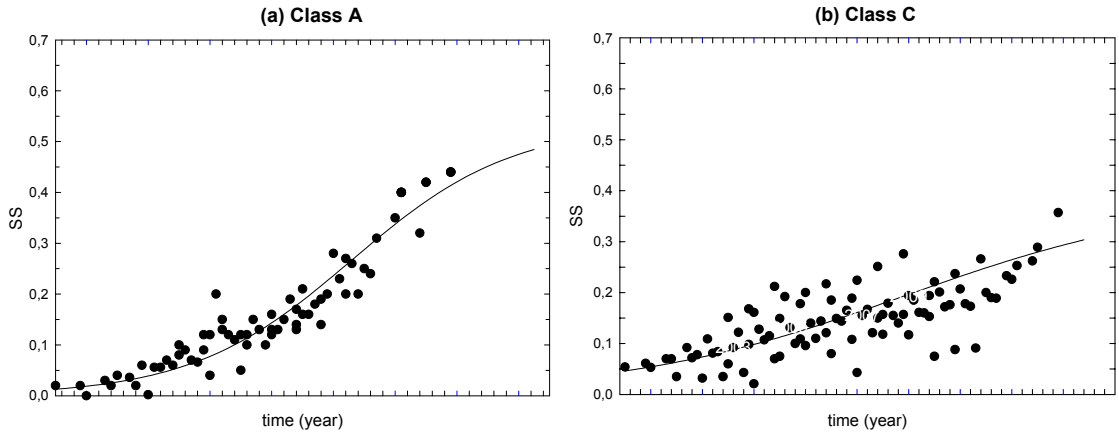

Figure 2 a, b. Source separation trends for communes belonging to classes A (a), and C (b). SS is indicated as a fractional value, while each division of the x axis corresponds to one year.

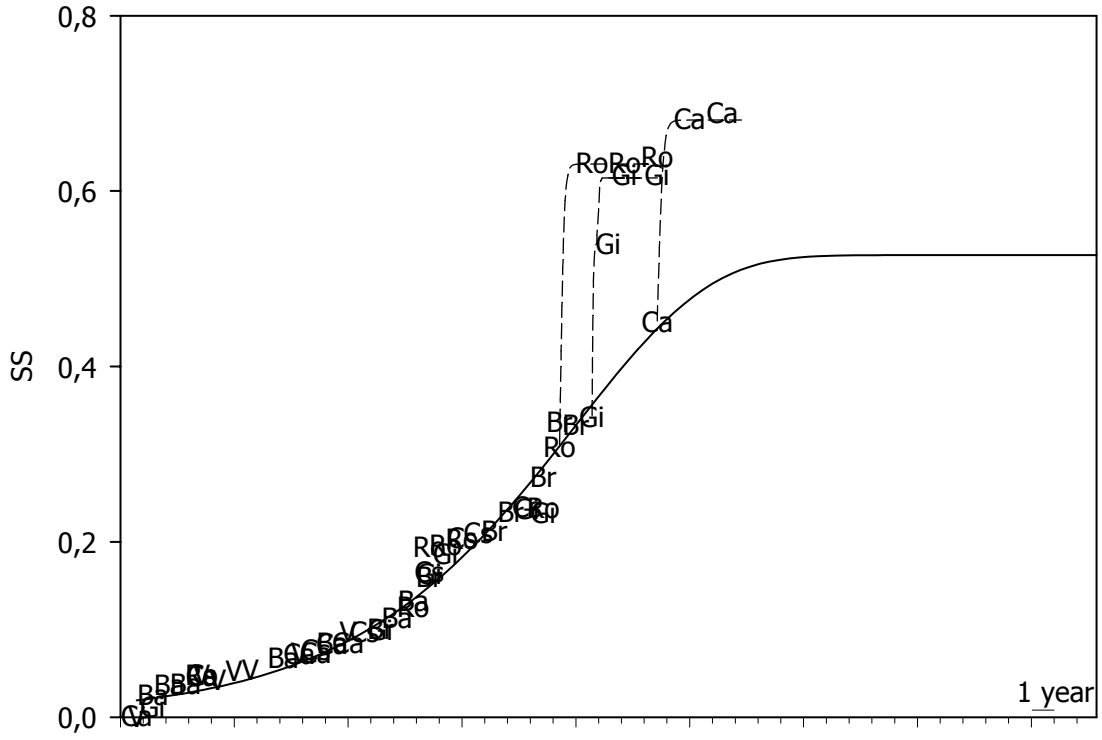

Figure 3. Effect of the transition to a source separation with the *door to door* modality. SS is indicated as a fractional value, while each division of the x axis corresponds to one year. (Ba = Bardonecchia, Br = Bruino, Ca = Cambiano, Cs = Caselle, Gi = Giaveno, Ro = Rosta, V = Verolengo)

3. EFFECTS OF SOURCE SEPARATION DEVELOPEMENT

The progressive passage to the *door to door* modality will bring to a new composition of waste collected with the source separation and also of the residual ones. Considering the differentiated

waste that can be treated in biological plants, the organic fraction will double abundantly during the transition from 35% to 50% or more; while the "green" fraction will grow less (data not shown). Evidently those two portions will decrease in the undifferentiated waste, in which it will be also evident the decrement of paper, cardboard, glass and ferrous fractions. In Table 6 the heavy increase, due to the transition to the *door to door* source separation, of material destined to biological treatments is emphasized supposing a 60% *door to door* source separation: the increase will bring to an abundant demand of structuring material necessary in particular for aerobic treatments. This will be a problem considering that the structuring fraction is already lacking.

Considering that the complete transition to the *door to door* modality will require long time and the different situations which characterize the Province of Torino, finally the coexistence of both modality of source separation (*road* and *door to door*) should be accepted. The objective of 50% could bring to 135.000 tons/year (estimated) of available "clean" organic material and to a value of about 3700 PCI (lower calorific power, kcal/ kg of dry residue) for the undifferentiated waste. Taking into consideration those factors it is possible to plan the development of waste management in the province of Torino. In Table 7, for each planning area, the estimated production of the biodegradable waste (organic and "green" fractions) for the year 2010 is reported together with the actual and expected potentiality of biological treatment plants (aerobic and anaerobic). Analysing data it is possible to evidence that the Province is characterized by a treatment plants potentiality which is not homogeneous for all the planning areas. In particular the potentiality of the South – East area is unproportioned respect to the high quantity of waste produced due to the presence of the city of Torino (basin 18). According to Table 7, considering the presence of small plants (Authorizations ex art. 33 d.lgs. 22/97) together with those managed by consortia, it is evident that the actual potentiality is almost enough to face Provincial demand, also that expected in 2010. Small plants have an irregular distribution and for this reason waste movement could have a negative environmental impact. This justify the high potentiality increase which has been foreseen in the years preceding incineration plant start up.

Table 6. Tons of organic and "green" material produced and tons of structuring material needed as support for the biological treatment with 35% of *road* SS and 60% of *door to door* SS.

Materials	SS 35% (tons)	SS 60% (tons)
Organic	60.000	170.000
"Green"	54.000	72.000
Structuring	57.000	121.000

Table 7. Biodegradable waste production expected for year 2010 compared with actual and expected potentiality of biological treatment plants. Values into brackets also include potentiality of small plants concerning Authorizations ex art. 33 d.lgs. 22/97.

	Production (tons/year)	Treatment potentiality (tons/year)	
Planning areas	Organic + "green" waste	Actual	Expected
South-West	61.000	45.000 (80.500)	115.000 (150.500)
South-East	134.000	40.000 (84.500)	74.000 (118.500)
North	25.500	21.000 (53.500)	41.000 (73.500)
TOTAL	220.500	106.000 (218.500)	230.000 (342.500)

4. CONCLUSIONS

The conducted research consented to study in a reliable way the possible evolution of source separation in the Province of Torino. Considering the territorial division for waste management and analysing source separation data from the start up, it was possible to foresee the expected scenery in the year 2010 when an incineration plant should be present.

First of all, it is possible to affirm that the regional objective of 50% of source separation is very difficult to be reached with the *road* modality, in particular for communes in classes B and C: in spite of this, few communes characterized by particular situation (e.g. touristic communes) might reach the threshold but only in long time periods.

On the other end, the newly introduced *door to door* modality seems to consent to achieve the regional objective also in a short period. With regard to this, at the moment, data of *door to door* source separation are few and belonging only to some communes of the Province and areas of Torino; notwithstanding that they are validated by similar results obtained in other Italian Provinces where this kind of source separation has been activated already for some time. Probably in the best situations, the source separation will raise the maximum and stabilize around values of also 60-70%, but it will not go any further. As a consequence of high percentages of source separation, the composition of differentiated and undifferentiated waste will change. In particular "clean" organic material destined to biological treatment will increase very much (220.500 tons are previsted for 2010).

In order to face the future situation, the Province of Torino has deem necessary to reorganize waste management and to provide for the enlargement of existing treatment plants or for the construction of further ones. In particular, regard to biological treatment, approximately the duplication of the actual potentiality has been planned. In this connection, the contribution of small private plants (Authorizations ex art. 33 d.lgs. 22/97) is not negligible for the Province and could be a problem in the future when stable high quantities of organic material will be collected. In fact, if this differentiated fraction will be managed by great plants of consortia, it is possible that the over plus of potentiality respect to the required one (220.500 tons) could be of 120.000 tons which corresponds to that of existing small plants. This will bring to a sub-use of great aerobic and anaerobic plants or to difficulties for smallest ones to find organic and structuring material.

Finally abundant quantities of compost will be produced through the aerobic treatment (about 150.000 tons): the high availability of "choice" compost will need to be considered at Provincial level, and probably also at Regional one in order to locate possible destinations of this product.

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